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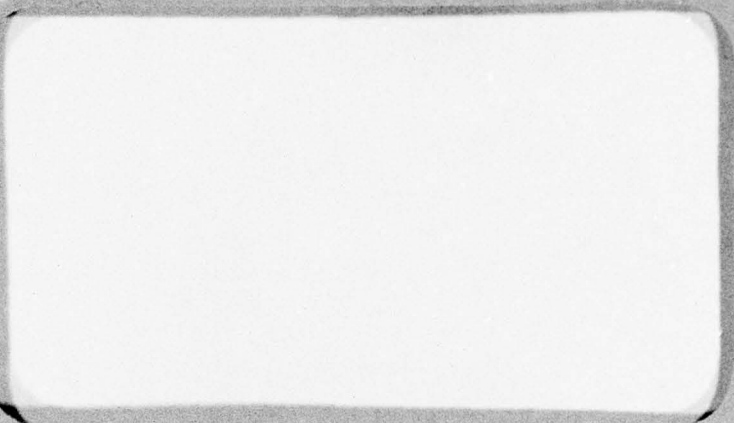
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FINAL TECHNICAL REPORT

DEVELOPMENTAL METHODOLOGIES FOR MEDIUM- TO LONG-RANGE ESTIMATES: EXECUTIVE SUMMARY (U)

September 1976

Sponsored by:

Defense Advanced Research Projects Agency

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Program Code Number	P6W10
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PREFACE

This document is one of a series of reports describing the research activities undertaken to complete Defense Advanced Research Projects Agency (ARPA) supported contract number MDA903-76-C-0255, entitled "Developmental Methodologies for Medium- to Long-Range Estimates." These reports describe the project's empirical, methodological, substantive, technical, and theoretical contributions.

The Final Technical Report is presented as a set of documents rather than a single report. They are

- A • Executive Summary,
- B • Long-Range Regional Forecasting Models,
 - The Soviet Force Effectiveness Model,
- D • User's Manual for the Long-Range Regional Forecasting Models,
 - E • *Program Documentation for Long-Range Regional Forecasting Models.*
- F • User's Manual for the Soviet Force Effectiveness Model, and
- G • Program Documentation for the Soviet Force Effectiveness Model.

The first three volumes substantively describe all research tasks, provide the rationale for research decisions, and report important findings. The remaining four volumes document the two computer programs delivered to the Defense Intelligence Agency/Directorate for Estimates (DIA/DE) for installation on the Defense Intelligence Agency On-Line System (DIAOLS).

The Executive Summary briefly describes the overall project. The volumes on the regional forecasting model and the force effectiveness model, by far the most substantive and complex of the documents, discuss the design and development of each of these models, respectively. The first reviews the regional models, identifies areas where improvements were made for DIA/DE, and presents the findings from sensitivity tests and computer simulations for Europe, the Middle East, Latin America, and Africa. The second fully discusses the development of the Soviet force effectiveness model. The volume is classified.

The remaining four volumes focus on the two computer models delivered to DIA/DE. A user's manual and program documentation have been written that provide all necessary information for using and maintaining the models.

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This report was prepared by:

John J. McIlroy, Ph.D., Project Director

Leo Hazlewood, Ph.D.

Janice Fain, Ph.D.

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EXECUTIVE SUMMARY

The Defense Intelligence Agency/Directorate for Estimates (DIA/DE) is charged with supplying military intelligence estimates to the Joint Strategic Planning System (JSTPS). In this capacity, the Directorate's mission includes generating estimates that, in whole or in part, provide the basis for national intelligence and security planning. Because DIA/DE is charged with supplying medium- to long-range estimates of external threat to the United States, it focuses on:

- World political relations, particularly those affecting developed and underdeveloped nations that are important to the United States because they are allies, suppliers of raw materials, strategically located, or opposed to U.S. interests.
- Future military capabilities, particularly technological advances that might surpass U.S. expertise. The technological sophistication of major U.S. adversaries is critical for future planning. Sound projections can ensure that the current U.S. lead is maintained.
- Likely courses of actions by other countries, changes in alignment patterns, economic growth, international tensions, and domestic unrest.

In the past, these important factors have been processed using traditional pencil and paper methods. However, with the completion of this project, DIA/DE has two on-line, user-interactive forecasting/simulation technologies. These technologies make initial forecasts more credible and permit alternative future environments to be examined.

They enable DIA/DE to

- Link present trends and developments and medium- to long-range futures more explicitly,
- Update forecasts rapidly when unexpected patterns occur in remote areas,
- Simulate alternative policies,
- Project alternative U.S., Soviet, and Chinese involvement in Europe, the Middle East, Latin America, and Africa, and
- Estimate total Soviet force effectiveness and evaluate Soviet potential to meet various projected future environments.

This Executive Summary describes the development of these important analytical technologies under Defense Advanced Research Projects Agency (ARPA) contract No. MDA903-76-C-0255, designed to improve the capability to forecast important factors that define the international military environment and have implications for long-range intelligence estimates. Two user-interactive computer models were developed in this project. The first enhances existing Department of Defense (DoD) forecasting capabilities (CACI, 1975b, 1974, 1973) by applying social science research methodologies to long-range forecasting of important economic, military, and political variables. The second major product developed is a model that enables DIA/DE to measure total Soviet force effectiveness for use in estimative intelligence. Together, these efforts constitute technological innovations that enhance the reliability, accuracy, relevance, timeliness, and therefore, the credibility of long-range forecasting for defense intelligence estimates and planning.

This project had four objectives:

1. Refine and equalize the existing long-range forecasting models developed for Europe, the Middle East, Latin America, and sub-Saharan Africa, previously developed under ARPA contracts for the Joint Chiefs of Staff (JCS/J-5).
2. Enrich the existing models by including the People's Republic of China as a major actor in the superpower simulation capability and adding the option to simulate the impact of political regime changes.
3. Develop a model to estimate future Soviet force effectiveness based on the Defense Intelligence Projections for Planning (DIPP) document, including the capacity of the Soviet Union to improve the quality and quantity of its major weapon systems and pose increased threats to U.S. interests.
4. Implement the enriched forecasting models and the Soviet force effectiveness model on the Defense Intelligence Agency On-Line System (DIAOLS) with a user-interactive capability to permit DIA analysts to forecast alternative futures by altering data, superpower behavior, or regime type, and/or forecasting parameters to simulate different courses of action.

RESEARCH DESIGN

To accomplish these objectives, CACI designed a two-part research program. The first task focused on improving and equalizing existing regional forecasting models and associated computer software. The second involved developing a Soviet force effectiveness model. To accomplish the first major effort, CACI

- Carefully reviewed the forecasting models for Europe, the Middle East, Latin America, and Africa by examining each forecast equation from a substantive and

statistical perspective to determine the validity of each. Equations that were inadequate or inappropriate were respecified and retested with empirical data.

- Upgraded the European model to the complexity of the less-developed regional models by re-estimating new parameters for the regional forecasting equations and using country-specific time-series parameters on investment, consumption, imports, and exports.
- Added the People's Republic of China to the superpower influencers by specifying equations to include China's importance.
- Improved the capacity to assess regime change to give DIA analysts the flexibility to simulate regime change by refining and increasing the number of government types, and specifying a set of forecasting equations with appropriate parameters to cause changes in forecasts when government change is simulated.
- Developed a user-interactive preprocessor, a main calculation program, and a report writing program so analysts can manipulate data, parameters, superpower behaviors, and regime change directly through DIAOLS computer terminals.
- Evaluated the sensitivity of the regional forecasting models and produced regional simulations by entering appropriate superpower, data, and parameter changes through the preprocessor and exercising the forecasting program.

The improved regional models have been installed on the DIAOLS. A user's manual (CACI, 1976l) describes the operation of the preprocessor, the forecasting program, and the report writing program. A second manual (CACI, 1976m) documents and discusses the logic of the computer program, presents all program statements, and describes each phase of the forecasting process.

To develop the Soviet force effectiveness model, CACI

- Reviewed approaches to measuring Soviet force effectiveness and, in consultation with DIA/DE, selected lethality, accuracy, and survivability for evaluating Soviet force effectiveness. CACI analysts identified appropriate data in the Defense Intelligence Projections for Planning On-Line System (DIPPOLS) to calculate Soviet force effectiveness.
- Programmed interactive force effectiveness model and structured an automated system for manipulating DIPPOLS data.
- Performed sensitivity tests and simulations using actual Soviet force characteristics for several combinations of different forces. The sensitivity tests evaluated the flexibility, accuracy, and reliability of the model.

The Soviet effectiveness model is currently operational on DIAOLS. A user's manual (CACI, 1976n) discusses the operation of the Soviet force effectiveness model and explains the options available to users. The system documentation manual (CACI, 1976o) discusses the computer program, its interface with DIPPOLS, and all other technical aspects of the software.

ACCOMPLISHMENTS

All phases of the research were completed so that offices with established DIAOLS linkages can access either the CACI regional forecasting models or the Soviet force effectiveness model. As proposed,

- The regional forecasting models have been standardized at comparable complexity for Europe, the Middle East, Latin America, and sub-Saharan Africa, and China has been added to the superpower influence set.

- The capability to influence forecasts by simulating regime changes was added and the models were made user-interactive.
- Sensitivity tests and simulations have been performed with each of the models and the three programs associated with the regional forecasting models (the pre-processor, forecasting program, and report generator) have been installed on DIAOLS.
- The Soviet force effectiveness model has been developed using information available in the DIPP on the number and characteristics of Soviet weapon systems.
- An equation was developed that selectively aggregates weapon characteristics, interfaces them with DIPP force level information, and generates estimates of Soviet force effectiveness.
- A program for the Soviet force effectiveness model that permits user interaction with the weapons system data and alternative assumptions about the growth and structure of Soviet forces has been implemented on DIAOLS and is presently available.

The two computer models considerably enhance DIA/DE's forecasting capability, as intelligence estimators can now generate and analyze long-range alternative futures for Europe, the Middle East, Latin America, and Africa, or alternative estimates of Soviet force effectiveness. In each case, the analyst now has available a computer technology that permits structures and assumptions of either model to be altered to reflect an insight about the phenomenon being studied. Furthermore, the intelligence estimator has been provided with guidelines on how to interface the long-range regional forecasts with estimates of total Soviet force effectiveness. As analysts become more familiar with both models, their sensitivities to the implications of the generated forecasts and estimates will increase. Moreover, questions that will tax the limits of the models will eventually be asked. Finally, as they gain currency

throughout the intelligence community, demands for increased sophistication and refinement can be expected.

The models produced by this research integrate traditional academic approaches and complex quantitative methodologies to develop tools that can be used to improve intelligence estimates. In addition, the research interfaced qualitative and quantitative techniques that are intermingled in any modeling effort and produced vastly improved, standardized, and user-interactive versions of CACI's regional forecasting models. Moreover, it produced the first generation of a user-interactive Soviet force effectiveness model that relies on highly sophisticated intelligence data. The lessons learned in completing these two major efforts should be intensely scrutinized by all potential users.

ADDITIONAL CONSIDERATIONS

CACI's past efforts in developing the regional forecasting models have involved collecting and organizing statistical information, applying statistical analytical techniques, examining the implications of data error, designing and constructing forecasting models, designing and developing user-interactive programs, applying regional versus country-specific forecasting equations, and so on. Each effort has clearly improved the reliability and validity of the regional forecasting models, thus considerably advancing the credibility of forecasts.

Even with these advances, continuing technology assessments suggest a number of unmet, yet very necessary, steps which must be taken to ensure that the best possible regional models are developed for the national security community. They include the following:

- Develop worldwide medium- to long-range estimative intelligence technologies. Currently, no model exists

for Asia. Limited effort would be required to expand the current system to include that region. Further, the current structure contains the United States, the Soviet Union, and the People's Republic of China as influential superpowers. This set could and should be expanded to include Japan and the major Western European countries.

- Develop stochastic mechanisms for superpower interaction simulation. While including additional superpower influences is a substantial step toward improving the realism of a worldwide model, only the independent effects of the superpowers will have been modeled. The action-reaction nature of superpower behaviors and the impacts of such activity on other nations can now only be indirectly simulated. These aspects can and should be modeled in greater detail.
- Explore and apply methodologies to enrich regional forecasts. Constraining the analyst's perspective to define sets of countries geographically has, to some extent, made modeling more difficult. One solution is to estimate country-specific parameters, an approach that has worked extremely well with the economic sector of the current model. However, when data are insufficient or inadequate, the relationships among environmental variables should be modeled for similar types of countries. These procedures should produce increasingly accurate forecasts.

The lessons learned from modeling Soviet force effectiveness should also be intensely evaluated. As expected, the data in the DIPP are more readily available for large weapons. Consequently, a force effectiveness model favoring the available data was developed. Thus, the effectiveness of general purpose forces (naval, tactical air, and ground) is less well assessed by the current model. During the project, CACI continually clarified DIA/DE's specific interests on Soviet force effectiveness. For example, the distribution of off-line and on-line systems became important, as did the distinction between nuclear and non-nuclear weapons. Furthermore, distinctions as to the role of specific

weapons (either offensive or defensive) sometimes became important in considering weapon effectiveness.

The current Soviet force effectiveness model discriminates between nuclear and non-nuclear weapons and off-line and on-line systems. It is also capable of aggregating different weapon systems to simulate specific missions. Other advances can readily be made.

- Identify forces by geographical region, permitting combinations of offensive and defensive capabilities in specific locations such as Europe, South Asia, and China.
- Evaluate Soviet force effectiveness of weapons in both an offensive and defensive role. This would considerably enhance the intelligence estimator's knowledge of the dimensions of force effectiveness and the overall effectiveness of specific forces analyzed in the DIPP.
- Develop measures of U.S. force effectiveness for offensive and defensive systems, located in selected geographical areas, to compare with Soviet force effectiveness measures. Such an analysis could eventually develop new technologies for quantitative net assessment.

Technology assessment is an ongoing process in which model builders and model users review and try to improve the range and quality of existing products. CACI's long-range forecasting models have been subjected to precisely this kind of scrutiny. This discussion identified new areas where further improvements should be made. The same is true of the Soviet force effectiveness model. As more users become acquainted with it, technology assessment will begin. The resulting feedback will contribute to the growth that must continue if forecasting and estimation capabilities within the Department of Defense are to become part of the policy-planning process in the national security community.

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Corporate Offices: 1815 North Fort Myer Drive, Arlington, Virginia 22209, Telephone (703) 841-7800
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